# FUTURE FORCE AND FIRST RESPONDERS: BUILDING TIES FOR COLLABORATION AND LEVERAGED RESEARCH AND DEVELOPMENT

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## ABSTRACT

Visions for the information needs and operational capabilities of the Future Force are similar to those for First Responders who comprise the backbone of Homeland Security personnel. There is also an increasing role for collaboration between Future Force warriors and First Responders in response to both domestic incidents and internationally through peacekeeping and related operational roles (US Army 2001; US Army 2004). The purpose of this position paper is to summarize the information environment of First Responders from the perspective of the IT/C4ISR community, seeking to highlight areas for collaboration, extension of research, and opportunities for leveraged R&D.

## 1. INTRODUCTION

Managing the assembly and dissemination of information has always been a key component of operational success for distributed forces. The advent of wireless technologies together with lightweight sensors and portable computing devices has perhaps made information dominance the most important aspect of operational success short of morale and training. A white paper states Future Force will "see first, understand first, act first, and finish decisively" (US Army 2001). Supporting such capabilities is the Joint Battlespace Infosphere (JBI), an integrated information platform to support operations at strategic, operational, and tactical levels (Marmelstein 2002). DoD units are not the only ones to benefit from such technologies. Increasingly, Homeland Security forces are developing "security informatics" for information analysis and coordination of counter-terrorism efforts (Chen et al. 2003). More broadly, there are efforts to support First Responders such as police and fire rescue services who may benefit from information from diverse sources. This paper describes the operational challenges of First Responders and complementary challenges in accessing and analyzing information from multiple sources to provide advanced

capabilities for command and control. Selected technologies for First Responder information integration are reviewed with comments on their applicability for leveraged R&D with the IT/C4ISR community.

## 2. OPERATIONAL ROLES AND INFORMATION NEEDS FOR FIRST RESPONDERS

While varying considerably in detail, envisioned operational capabilities and information needs of First Responders are broadly comparable to those of Future Force warriors. Future Force foresees unprecedented access to information provided to field commanders enabling decisive, decentralized decision making while ensuring coordination among diverse units through a common operational picture provided by information technologies (US Army). First Responders have similar operational and information needs as they must coordinate actions of diverse units while providing those units the information needed for rapid and decentralized decision making in response to rapidly changing conditions. Consider, for example, response to a fire, which has significant information needs for situational awareness as well as coordination of a diverse operational force (described below and depicted conceptually in figure 1).

Situational awareness: First Responders require information about the plan of the building, including access paths, location of stovepipes, lockboxes, fire walls, and load bearing walls. Information from building sensors about heat and smoke are also desirable, and can be augmented by mobile sensor data regarding dangerous airborne chemical and biological agents. The approximate number and location of building occupants is needed to coordinate search and rescue operations. Surrounding the building, location of fire hydrants, utility shutoffs, and reports on water pressure are critical to the incident commander when deploying resources. An inventory of hazardous materials in the building and surrounding

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facilities must be quickly determined. All of this information must be combined and assessed to provide a common operational view for command-and-control. Furthermore, as fire and smoke can develop rapidly, and as new information becomes available (e.g., structural conditions, presence of building occupants, location of operational personnel), the common operational view must be quickly and continuously updated.
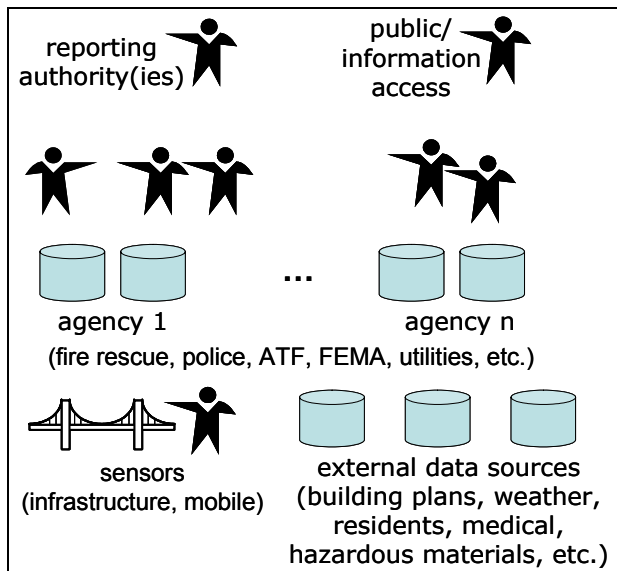


Fig. 1: Information sources and personnel supporting First Responder operations

Operational teams: First Responders are drawn from a wide variety of personnel, including police and fire rescue teams; however, they may be supported by other professionals such as hazmat teams, local utilities, plant and facility operations personnel, and other local officials. The number of such First Responders and associated agencies is very large (e.g., a case study of Gainesville, Florida reveals at least 16 agencies (O'Brien and Soibelman 2004), not including local hospital personnel or State and Federal Homeland Security official that may participate such as the State Fire Marshal, FBI, ATF, and FEMA). Coordination of the broad variety of First Responders requires considerable effort. The Department of Homeland Security has recently issued a National Incident Management System (NIMS) to help determine common procedures and guidelines for determining a chain of command when responding to an emergency (U.S. Department of Homeland Security 2004). However, like Future Force warriors, First Responders generally work in distributed teams and must make rapid, decentralized decisions. There is a need for the common operational picture to be sent to and updated by distributed teams of First Responders.

Operational roles: First responders also have diverse operational roles. With respect to response to a fire, First

Responders have highly specialized roles in terms of search and rescue, combating the fire with various equipment specialists, triage and medical services and evacuation for the injured, hazardous materials handling teams, and in certain circumstances special personnel and equipment for sensing and scouting. The diversity of these roles broadly mirrors the specialized roles played by DoD forces. Beyond direct response to an emergency, there are important supporting roles for First Responders, including crowd control, directing information to the public and public officials (for example, evacuation information), and coordination with utility and infrastructure maintenance personnel.

## 3. COLLABORATION BETWEEN FUTURE FORCE AND FIRST RESPONDERS: CHALLENGES AND OPPORTUNITIES

Beyond broad conceptual similarities between First Responders and Future Force in terms of coordination of operational teams and needed situational awareness, there are circumstances where direct collaboration between these forces is needed. Domestically, Future Force may be deployed to support relief operations in response to a natural disaster or deployed in response to a terrorist attack. For example, Navy and Coast Guard forces might coordinate with local law enforcement in response to an assault on high value targets in major ports such as Tampa or San Diego. With respect to overseas operations, an Army white paper envisages the need for "modular" forces that can be deployed flexibly in response to changing conditions, particularly over the course of an extended expeditionary campaign (US Army 2004). Given current experience in Iraq and Afghanistan, it is reasonable to expect that such modular units will coordinate with foreign First Responder forces as well as with other US units. International peacekeeping and relief operations are also likely to require coordination between DoD forces and international domestic and coalition forces.

Both domestic and international coordination between First Responders and Future Force face similar challenges and opportunities to leverage local knowledge and coordinate disparate forces. A recent training exercise in San Diego simulating terrorist use of a "dirty bomb" featured use of data about building location, water supplies, roads, and emergency centers presented using a geographic information system (GIS) (Keefe 2004). Real time data from distributed sensors mounted aboard trucks and helicopters provided data about winds that allowed prediction of the path of the radioactive plume. This allowed coordination of response efforts, including a simulated reverse 911 system to alert civilians of the need to evacuate. The presence of integrated information resources provides considerable opportunities to a

technologically savvy Future Force warrior able to leverage these sources. Information such as building plans, wind conditions, GIS terrain data overlaid with utility information, and location of First Responders can only aid operations.

Of course, the challenge is to integrate the information resources available to First Responders with those of Future Force. Despite complementary calls for "smart cities" (Roush 2001), deployed technology like that in San Diego remains the exception rather than the norm domestically as well as internationally. While more and more agencies maintain useful data in electronic format, the number of sources and their local nature (e.g., 16+ agencies in Gainesville with useful information to First Responders) make integration difficult both in terms of integrating formats and cleansing conflicting information. For example, 20-30% of the addresses in the regional utilities and phone directory databases in Alachua County, Florida do not match and the local coordinator in charge of generating a common database for the county reports similar efforts across the State. These integration challenges grow greater internationally, where data sources may be sparser and less sophisticated (but consequently may be more valuable given limited information and lack of local knowledge).

## 4. CONCEPTUAL SIMILARITIES BETWEEN IT/C4ISR AND FIRST RESPONDER INFORMATION ENVIRONMENTS

The similarity between operational roles extends to supporting information environments. According to Milligan and Hendler, "… Future Force commanders, warfighters, and other combatants need an information management and exchange capability that supports tailorable, dynamic, and timely access to all required information to enable real-time planning, control, and execution of [their missions]…" (Hendler and Milligan 2003). The same can be said for First Responders, who need a way to share information among the disparate computing resources of multiple State, local, and Federal agencies that may be involved in responding to an emergency. For example, just as the Future Force warrior will have an array of sensors and portable computing devices, First Responders are increasingly deployed with information technologies to improve capabilities and life safety (Jones and Bukowski 2001). Similarly, there are emergency management centers comparable to theatre level command and control centers. In between there is coordination between agencies handling an emergency similar to JTF operations, experiencing the same needs for security, privacy, and just-in-time delivery of the right information to the right people.

The above-mentioned requirements have resulted in specifications and mandates for information management and sharing in their respective communities. In the case of IT/C4ISR, the proposed JBI is aimed at providing the necessary capabilities in the form of an architectural framework together with a set of interface specifications to support the processing, integration, aggregation, and distribution of heterogeneous information from disparate sources at various levels of detail: from theater-level briefings for the command center to specific situation reports for the warfighter (Marmelstein 2002).

As such the JBI framework will provide four essential capabilities: (1) *Force templates* to support the controlled incorporation/connection of information providers and consumers (clients) into the JBI platform. (2) *Fuselets*, which are lightweight, trusted programs to transform the raw (possibly sensitive) information into knowledge that is sharable with other clients connected to the JBI. (3) A *common, object-based model* for representing the shared knowledge in a homogeneous manner. (4) A *set of supported transactions for information sharing* across the JBI clients which includes the ability to advertise and publish new content, query for existing content, and subscribe to change/update notification events from other clients. A high-level overview of the JBI framework is depicted in figure 2.
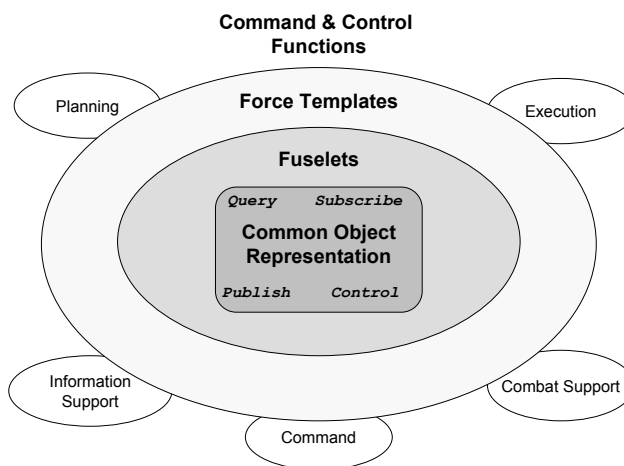


Fig. 2: JBI framework (Marmelstein 2002).

It is worth noting that JBI assumes that all clients have a similarly high-level of technical sophistication and are capable of generating the necessary interface code to participate in JBI. In contrast, the Department of Homeland Security has recently announced and approved the National Incident Management System (NIMS) specification (U.S. Department of Homeland Security 2004), which outlines a standardized approach to unify federal, state, and local agencies for incident response. Given the large number of possible collaborators as well as the significant discrepancies in the level of technical sophistication among them, NIMS provides a set of

policies, principles, and organizational procedures rather than a concrete information infrastructure. Key features of NIMS are: (1) a unified incident command system for management of all incidents and coordination across jurisdictions; (2) a common communications and information management system; (3) a set of polices and mandates for ensuring the preparedness of First Responder agencies as well as the public; (4) a joint information system to update the public with accurate incident information; and (5) a NIMS integration center which provides strategic direction and oversight.

Given this mandate, we have observed that many agencies with similar capabilities are starting to develop sharing systems that can provide some of the functionality outlined in NIMS. In the following (sec. 5), we briefly high-light some of these projects and propose ways to leverage the technology in support of JBI (sec. 6).

## 5. SURVEY OF RELEVANT TECHNOLOGIES IN THE FIRST RESPONDER DOMAIN

There is a significant amount of research and development in support of First Responders including homeland defense. We briefly highlight some of those which we believe could impact the IT/C4ISR community.

The National Institute of Justice (NIJ), with its history of developing standards for law enforcement and its close working relationships with State and local public safety agencies, has invested considerable resources in providing First Responders with new technologies for sharing information and facilitating collaboration among cooperating agencies. For example, the AGILE program (Advanced Generation of Interoperability for Law Enforcement, http://www.nlectc.org/agile/) pulls together all interoperability efforts within NIJ and serves as the point of contact for coordinating interoperability initiatives with other projects, both within the Department of Justice as well as with other Federal, State, and local agencies.

Some of the first technologies that have been developed under AGILE include an audio gateway for tying together incompatible radio systems (ACU-1000), an image dissemination system for rapid distribution of information on missing children, and an information integration system to enable information sharing between law enforcement agencies (INFOTECH), just to name a few. AGILE is an important first step forward in collecting, organizing, evaluating, and disseminating technology solutions to facilitate/improve data sharing and collaboration in the First Responders domain. In the context of IT/C4ISR the image dissemination and the information integration systems, for example, could be offered for mission planning and data fusion in the form of JBI services.

The Florida Law Enforcement Data Sharing Consortium (http://druid.engr.ucf.edu/datasharing/) is a partnership of major law enforcement agencies along the I-4 corridor in Central Florida. The goal of this consortium is to develop a decentralized sharing architecture that provides secure access to existing agency systems, while allowing the agencies to retain autonomy over their data. An initial prototype for the sharing of pawn data from agencies in six counties and over 40 jurisdictions is being developed using Web services technology for accessing and querying one or more local databases and XML as the underlying exchange model for transporting queries and results between requestors and the data sources. The sharing consortium is continuously adding new data sources and services to their prototype system and could provide the JBI Information Directorate with valuable experiences regarding the implementation of their sharing architecture to integrate heterogeneous agencies.

The COPLINK software which was jointly developed by the Artificial Intelligence Lab at the University of Arizona and Tucson Police Department with funds from an NIJ Grant, organizes and rapidly analyzes structured and seemingly unrelated data, currently housed in various incompatible databases and record management systems, over a secure intranet-based platform (http://www.coplink.net/index.htm). COPLINK thus allows police to target violent criminals by linking various databases—including sex-offender registries, gang databases and inmate records—providing ready access to information that otherwise requires a time-consuming search through each system. COPLINK is currently used by several police departments in the country; however, the underlying integration, inferencing, and association rule mining technologies could be readily applied to the intelligence community or applications related to DoD.

Among the academic research efforts, the SEEK project (Scalable Extraction of Enterprise Knowledge) at the University of Florida is directed at developing *scaleable data access and extraction technology* for overcoming some of the problems of assembling and integrating knowledge resident in legacy information systems and to make it available for analysis and decision-support (O'Brien et al. 2002). Besides information sharing in the public safety domain, development of theory and knowledge in this area is relevant to many other applications that depend on integrated access to heterogeneous information including tactical situation analysts in complex, data-rich environments.

SEEK follows established integration methodologies (e.g., TSIMMIS (Chawathe et al. 1994), InfoSleuth (Bayardo et al. 1996)) and provides a modular

middleware layer that bridges the gap between legacy information sources and decision makers/support tools. However, unlike existing approaches, it provides tools for extracting knowledge from the legacy source to support configuration of the mediators and wrappers. Furthermore, SEEK also enables step-wise refinement of wrapper configuration to improve extraction capabilities.

For example, the SEEK extraction technology was instrumental in developing a data pump for the City of Gainesville Fire Rescue (GFR), allowing them to quickly convert incidence response data from their native Emergency Computer Aided Dispatching (ECAD) format into a format that is compliant with the National Fire Reporting System (NFIRS) (see also nfirs.fema.gov). Using SEEK, the authors were able to quickly extract and augment the schema information that was available for GFR's ECAD system and provide the necessary translation rules for the development of a translator (wrapper) that drives the NFIRS data pump. Using the data pump, fire fighters or EMS technicians, will be able to submit their final ECAD reports to NFIRS without having to retype the information into an NFIRS data screen which is currently the case, saving time and cutting down on errors. Figure 3 shows a snapshot of one of the output screens from the NFIRS pump after data from an ECAD file has been parsed into the proper NFIRS templates.



Fig. 3: NFIRS data dump.

As another example, of how SEEK technology has been applied to the First Responder domain is shown in figure 4. This figure shows a screen capture of a database synchronization tool for a tablet PC that simplifies the capture of inspection data for fire hydrants (or any other field deployed infrastructure). Specifically, the application allows the inspector to download the hydrant database or portion thereof to the tablet PC and then make updates to individual records based on the observations in the filed. Depending on the connection type (e.g., weekly connected, disconnected) the inspector can chose to incrementally update the master database in the station after each change or submit all updates in batch mode upon returning to the station. If the target record in the master database has already been updated by somebody else, the synchronizer tries to identify if a conflict exist or if the different updates are affecting different parts of the record and can thus proceed. In both cases the user will be noted and an entry will be made in the update log.
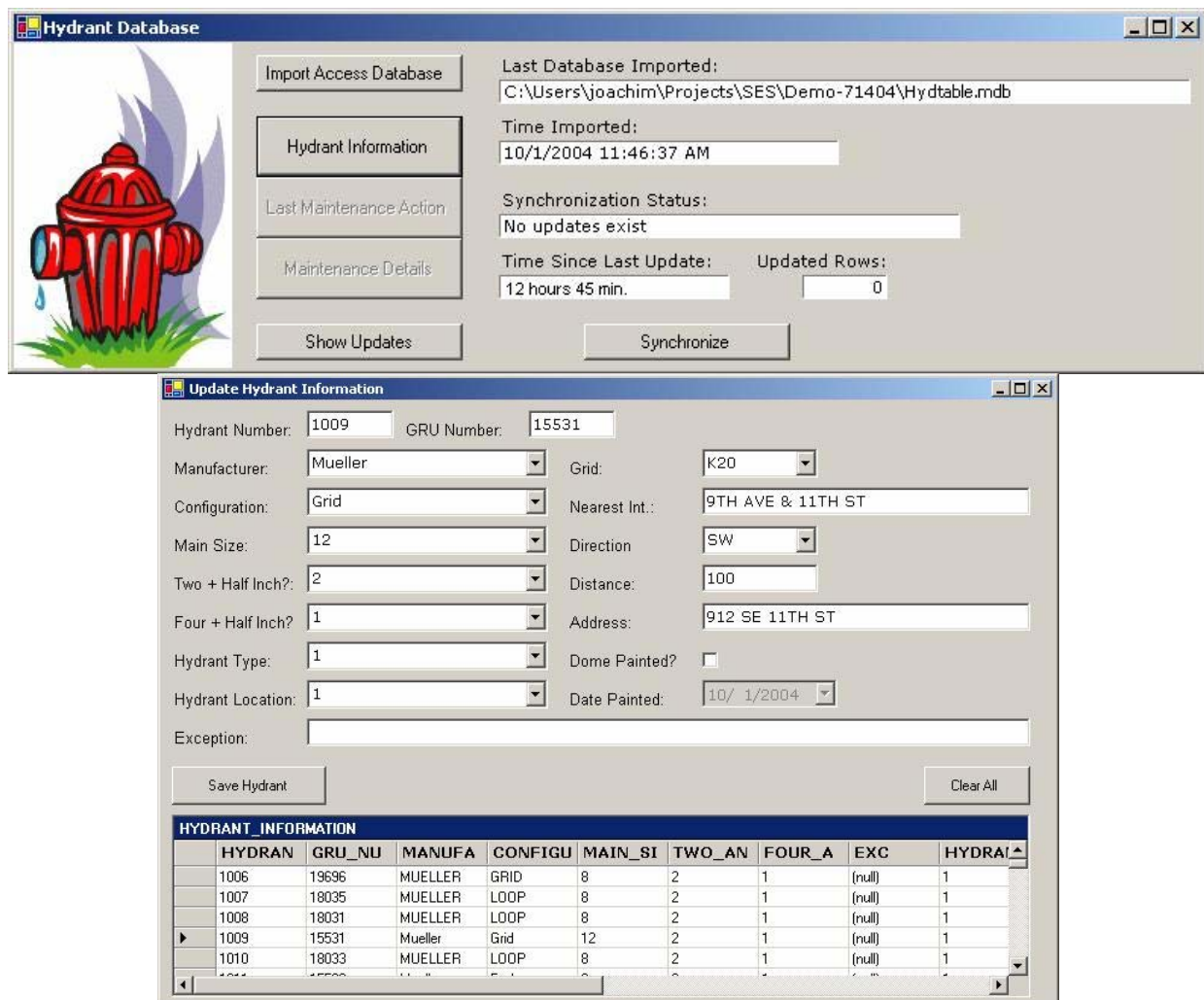
Fig. 4: Database synchronization tool for tablet PC.

SEEK technology enables rapid connection to heterogeneous data sources, allowing development of useful tools such as the NFIRS pump and Hydrant database synchronization tool. Its broader use, however, is to enable connections between heterogeneous data sources and decision support tools. As such, SEEK and related technologies promise to extend the usability of frameworks such as the JBI. Using the SEEK toolkit to extract and compose knowledge resident in data sources imposes only a minimal programming burden on their owners (compared to building a connection without a tool), as such making data available to Future Force that may otherwise be practically inaccessible given the speed of deployments.

## 6. Collaboration and Extension of Future Force and First Responder Information Systems

It is the assessment of the authors that the level of technology for command-and-control provided by the JBI is greater than that currently available to First Responders, and hence Homeland Security personnel could benefit from adapting DoD systems. On the other hand, we see four benefits for the IT/C4ISR community through closer integration and support for First Responders:

1. Continued validation of JBI and related technologies in practice through adaptation for operational support of First Responders.

2. Establishing an emergency management testbed for validating and extending IT/C4ISR technologies.

3. Opportunities for leveraged R&D between DoD and Homeland Security agencies.

It has been the authors' experience, however, that the semantic heterogeneities of First Responder information systems are extremely high, posing challenges to current IT/C4ISR technologies. As noted by Marmelstein (2002), ontology mappings are important for support of diverse

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coalitions, but are speculative in the context of the current JBI. Hence, the fourth benefit:

4. Due to extreme heterogeneity of systems and practices, First Responder coalition operations may hold important examples and potential lessons for IT/C4ISR research and development.

The Future Force will coordinate with diverse coalitions (other military, international and homeland First Responders) and draw information support from a variety of sources (e.g., local building plans to support urban tactical operations). Working closely with Homeland Security and First Responder coalitions has the potential to both drive development and expand the scope of IT/C4ISR technologies, ultimately speeding accomplishment of Future Force objectives.

## ACKNOWLEDGEMENTS

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## CONCLUSIONS

First Responders and Future Force personnel have complementary information needs for situational awareness and coordination of distributed forces. They also may need to collaborate and hence supporting data sources and technologies should be linked for maximum operational effectiveness. Given similarity of information needs and possibilities for collaborative actions, there are opportunities for leveraged R&D to test and extend technologies such as those comprising the Joint Battlespace Infosphere. The heterogeneity of information sources available to First Responders poses particular challenges for existing technologies but also opportunities for technologically sophisticated forces to improve real-time planning, control, and execution.